

Track B

Electricity Generation – Fuel of Choice?



*Natural Gas Technology:
Investment in a Healthy U.S.
Energy Future*

May 14, 2002

Joseph P. Strakey

Director, SCNG

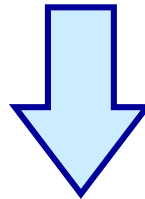
Strategic Center for Natural Gas



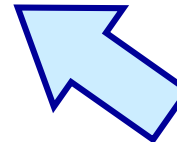
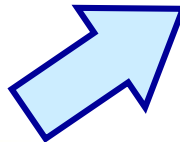
Electric Power Fuel Choice Considerations

Supply

- Cost / Volatility
- Availability / Reliability
- Characteristics / Emissions



Fuel Choice



Technology

- Capital / Operating Cost
- Performance Characteristics

Policy

- Regulations
- Incentives



Technology Development - the Key

- **Gas Supply, Infrastructure, Storage**
 - Existing fields
 - Marginal/Unconventional Resources
 - Frontier Resources
 - Increased Market Access
- **Advanced Power Systems**
 - Fuel Cells
 - Turbines
 - Hybrids
 - Vision 21

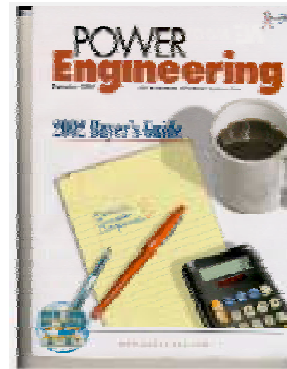


High Efficiency Engines and Turbines Program “HEET”

Building on Success of ATS



General Electric 7H (ATS)
400 MW, 60% Efficiency



Projects of the Year 2001
Editors Choice Award

Bright Lights Award
2000

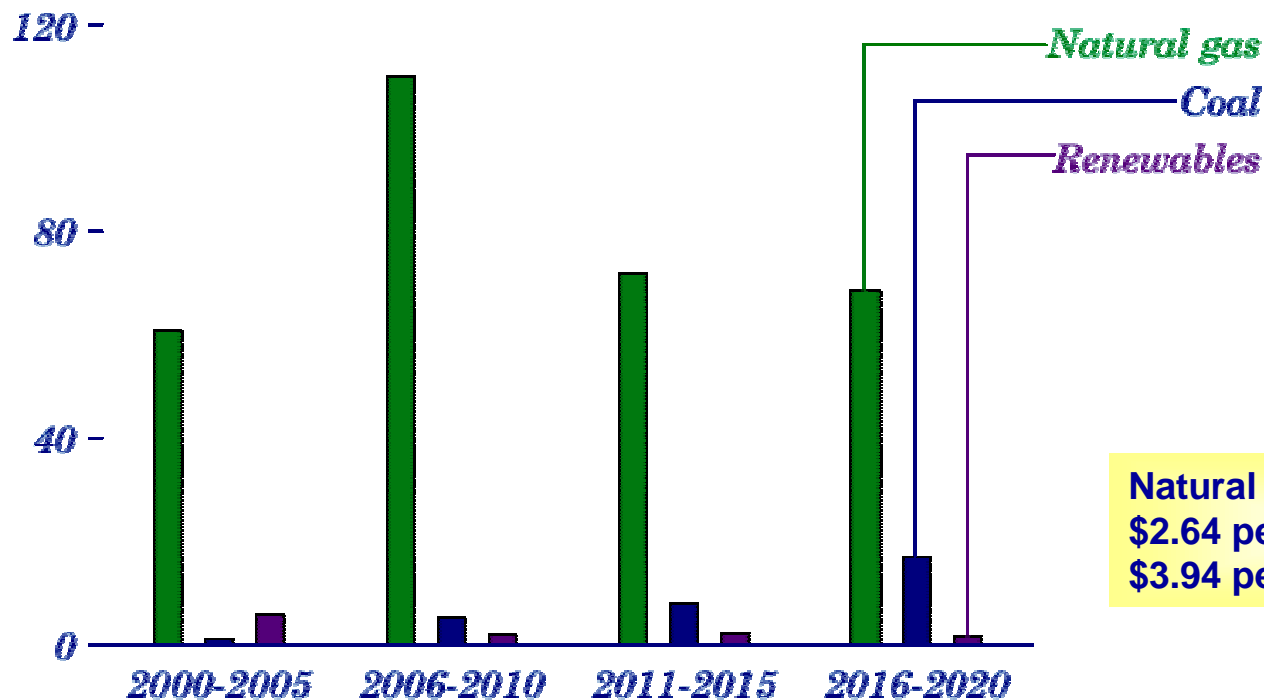


Siemens - Westinghouse 501GS
375 MW, 59% Efficiency



Generating Capacity Additions by Fuel Type (gigawatts)

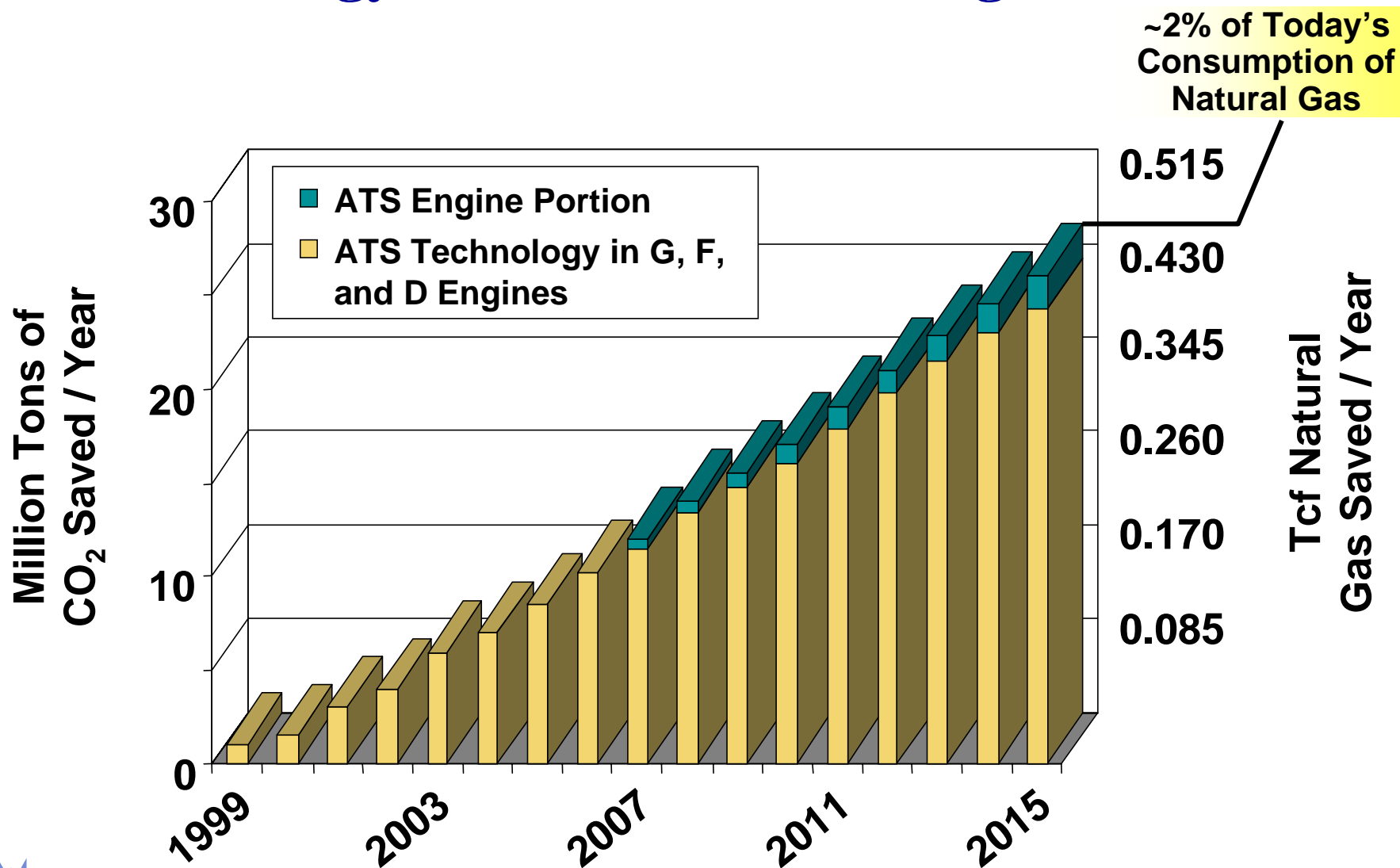
**Total: 355 GWe
88% CT or CC**



Natural Gas Prices:
\$2.64 per MCF in 2002
\$3.94 per MCF in 2020



Technology Infusion Into Existing Products

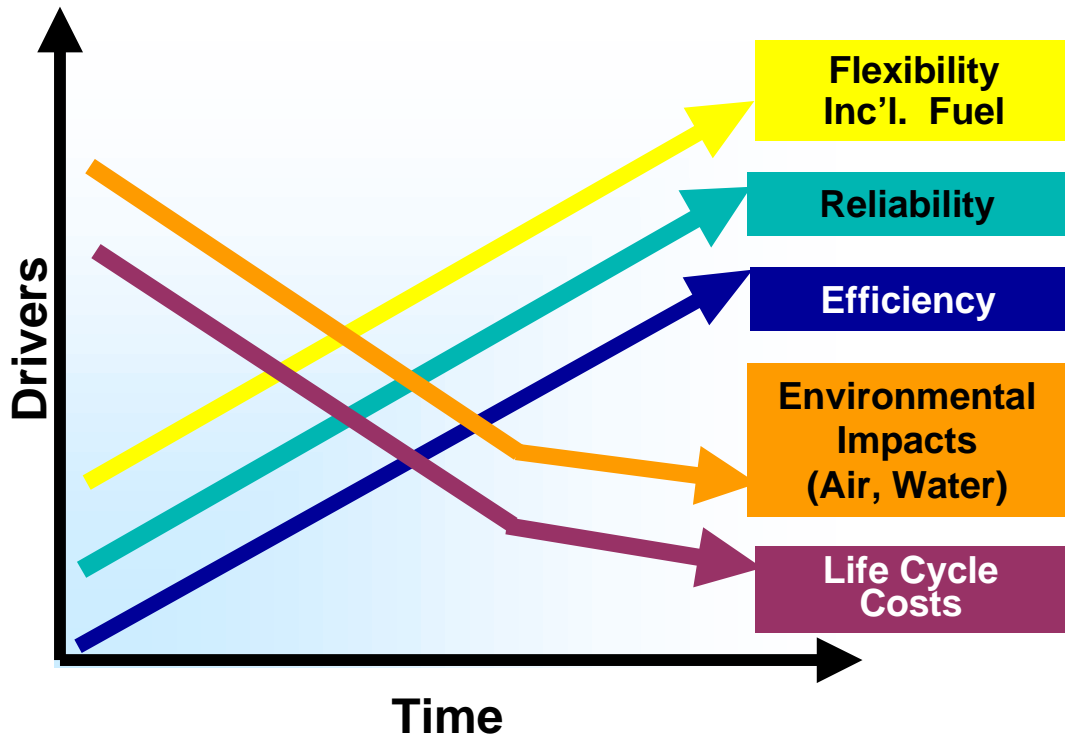


Siemens Westinghouse Power Corp. a, August 2001

Strategic Center for Natural Gas

HEET Program

Goals/Objectives



Technology Roadmaps

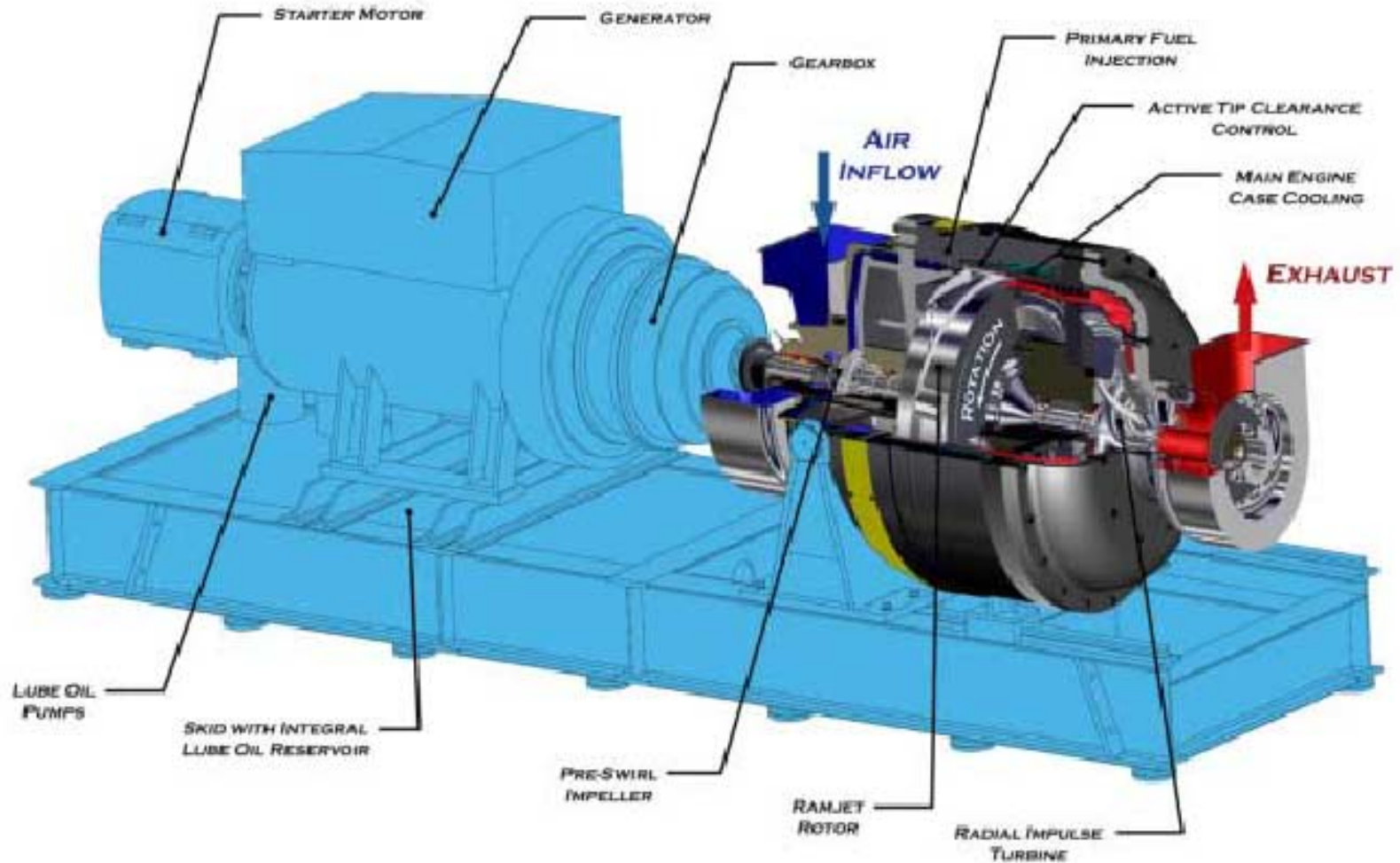
- **Materials**
- **Combustion / Emission Reduction**
- **Aero / Thermal**
- **Instrumentation / Controls & Sensors**
- **Design Tools**

Distributed Generation: Options for the Future

- Customer choice
- Siting flexibility
- Opportunity fuels
 - Biomass, landfill gas, anerobic digester gas
- Less capital investment risk
- Efficient, reliable, secure, environmentally benign
- Elimination of transmission and distribution investment requirements and line loss problems



Ramgen 2.8 MWe Generator



Source: Ramgen Corp.

Fuel Cells and Hybrids



Fuel Cell Technology Potential

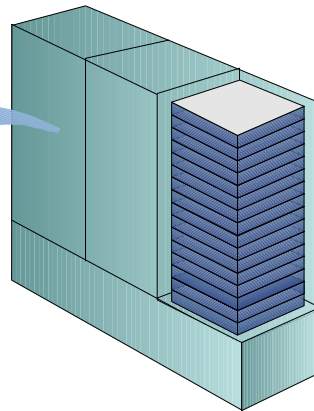
- **Order-of-magnitude potential:**
 - Order-of-magnitude reduction in cost expected
 - Near factor of two improvement in efficiency through hybridization
- **How:**
 - Breakthroughs in ceramic materials
 - Design innovations leading to high power densities
 - Compact fuel processing and thermal integration
 - Incorporation of semiconductor industry manufacturing techniques
 - Improvements in power electronics
- **Result: Deeper penetration, wider application, dramatic cost reduction**



Solid State Energy Conversion Alliance

Core Module for Multiple Applications

Transportation



Core Module

Stationary



Military



Strategic Center for Natural Gas

Public Economic and Environmental Benefits

Economic

- **Nearly 80 GW/year total new/replacement electric generation global market by 2010**
 - 2% growth and replacement
 - \$32 billion/year at \$400/kW
- **Sales Residential - 25 million homes U.S. & 50 million homes Europe**
 - \$150 billion at \$400/kW
- **Potential Truck 2 GW/year APU sales U.S.**
 - \$0.8 billion/year at \$400/kW
- **Ultimate Long-term Economic Impact**
 - 55 million vehicles/year global transportation market
 - \$200 billion/year at \$50/kW

Environmental

- **Lower emissions**
 - 60% efficient fuel cell hybrid systems cut CO₂ by 1/2
 - Fuel cells virtually eliminate NOx in stationary and transportation applications



SECA Goals and Applications



2005

- **\$800/kW**
 - Long-haul trucks
 - RVs
 - Military
 - Premium power

2010

- **\$400/kW**
 - Residential & industrial CHP
 - Transportation auxiliary power



2015

- **Vision 21 power plants**
 - 75% efficient
- **Hybrid systems**
 - 60–70% efficient



SECA Players / Efforts

Universities, National Labs, Industry



Honeywell

ARGONNE
NATIONAL LABORATORY

THE
UNIVERSITY
OF UTAH



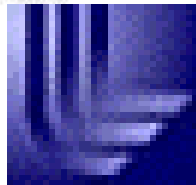
Battelle

Pacific Northwest
National Laboratory

SIEMENS
Westinghouse

Arthur D Little

OAK RIDGE
NATIONAL
LABORATORY



UNIVERSITY OF
FLORIDA



NEXTECH

MATERIALS

TMI
SYSTEMS



DELPHI

NORTHWESTERN UNIVERSITY

LOS ALAMOS NATIONAL LABORATORY

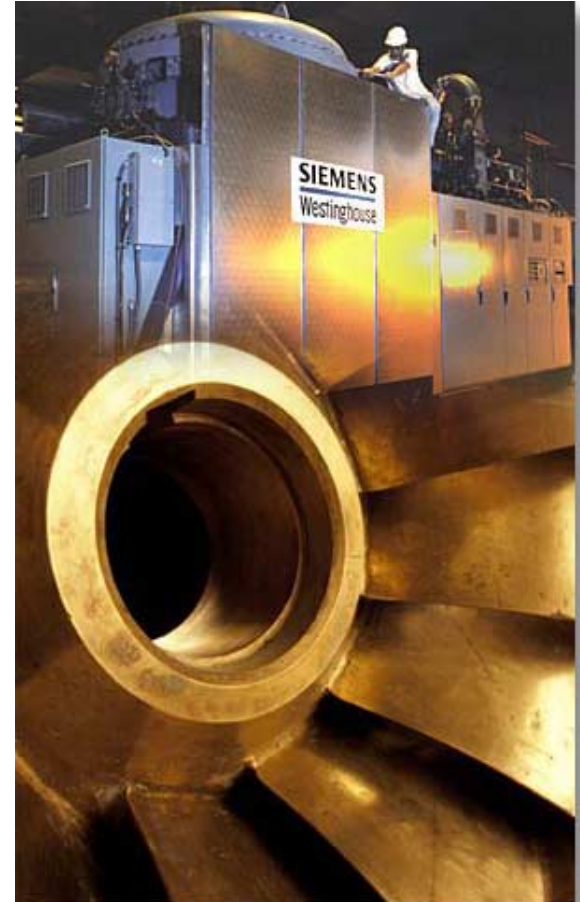
Georgia Institute
of Technology



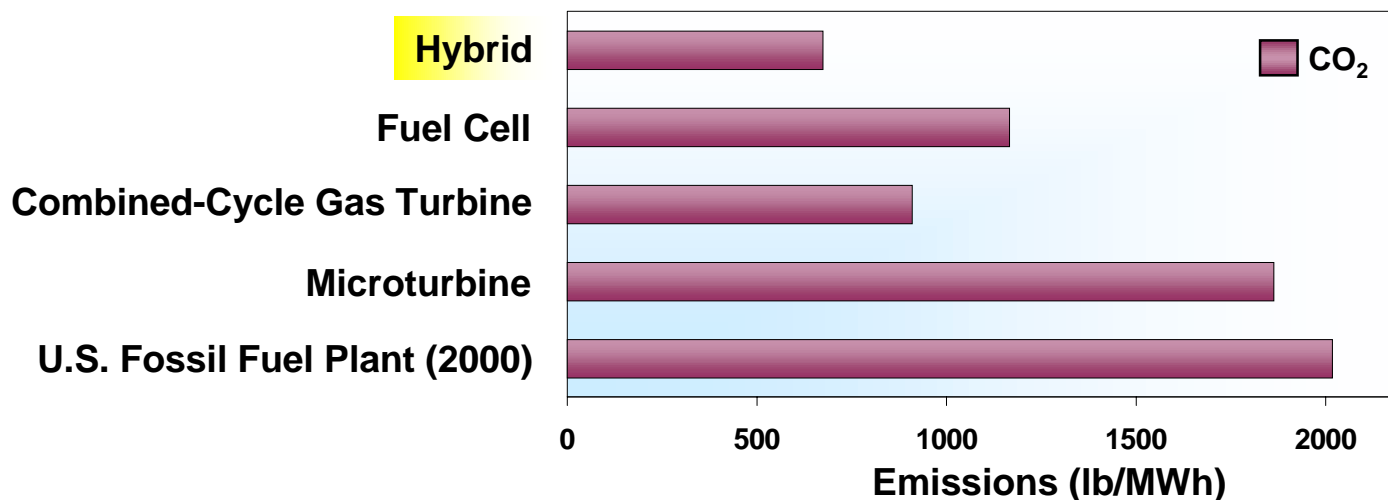
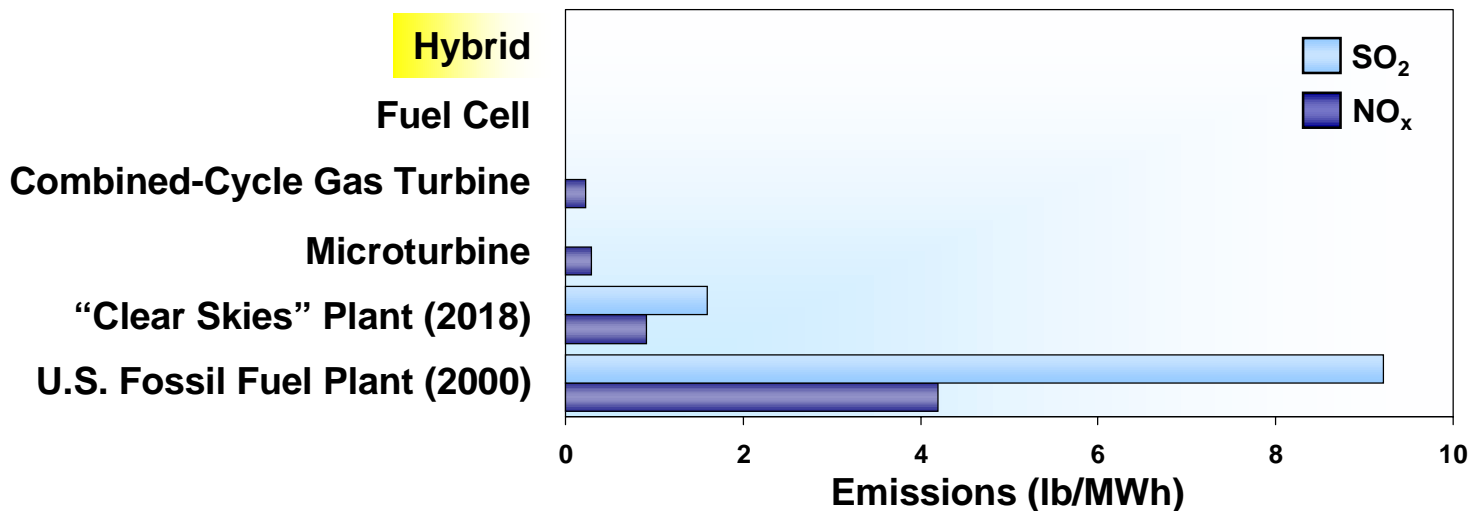
Strategic Center for Natural Gas

Hybrids: Results from Five 1998 PRDA Studies

- Electrical efficiencies of $>70\%$ are possible
- Systems with efficiencies of about 65% produce much lower cost of electricity
- Initial program should start with sizes significantly less than 20 MW
- Off-the-shelf turbines poor fit for large-scale hybrid systems

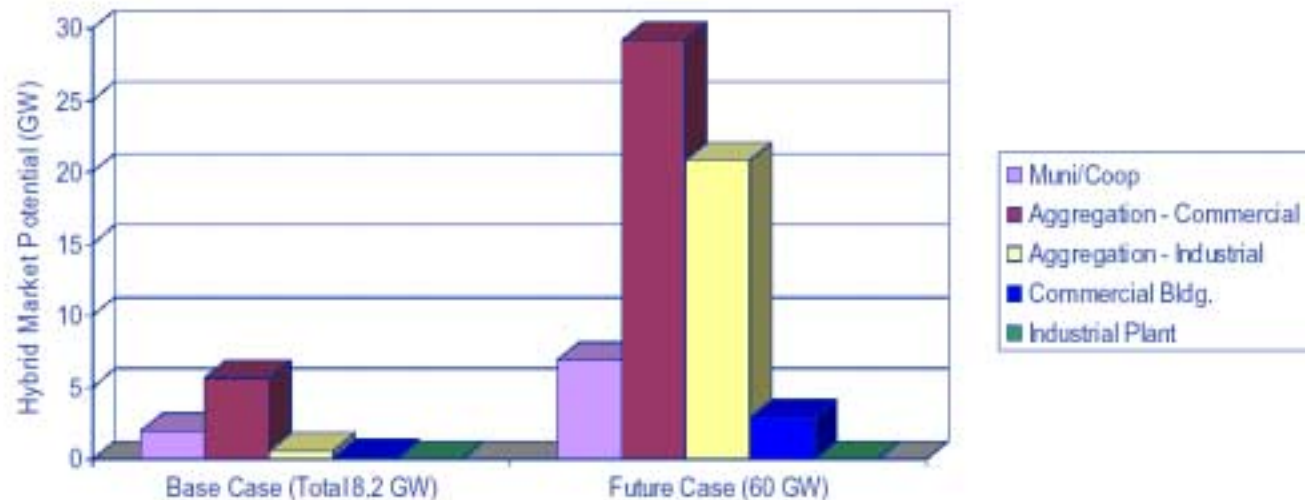


Hybrid Efficiency Leads to Low Emissions



Plant Estimates: D. Smith, NETL
Hybrid Estimates: L. Berkshire, NETL
Other Technology Estimates: S. O'Brien, UTC Fuel Cells

Market Potential for Hybrid Systems



- **Current (2005) hybrids can capture 8.2 GW of market share on COE basis in 15 – 25 MW size**
- **Future (2010+) hybrid system can potentially capture 60 GW of market share**
- **DOE's Industries of the Future identified “addressable hybrid market” of 70 GW by 2010 in 0.25 – 20 MW size**

Current Hybrid Projects

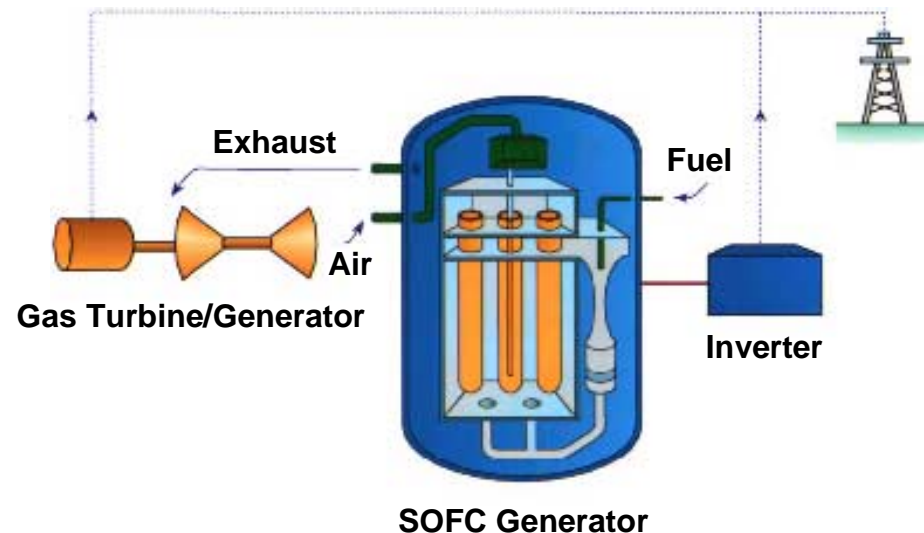
- National Fuel Cell Research Center
- Rolls-Royce
- Siemens Westinghouse Power Corporation
- Fuel Cell Energy
- Honeywell International



Siemens Westinghouse

Solid Oxide Fuel Cell / Gas Turbine

- World's first combined-cycle SOFC / GT
- 200 kW proof-of-concept demonstration
- Operated > 1,000 hours
- Located at and operated by NFCRC
- 300 and 550 kW demos planned



FuelCell Energy

Direct Fuel Cell / Turbine Sub-Megawatt Hybrid System

- First demonstration of indirect fuel cell turbine hybrid system based on MCFC technology
- Completed 4,700 hours testing with electrical efficiency of 52%
- Conceptual and engineering design of 40-MW hybrid DFC/T hybrid power plant



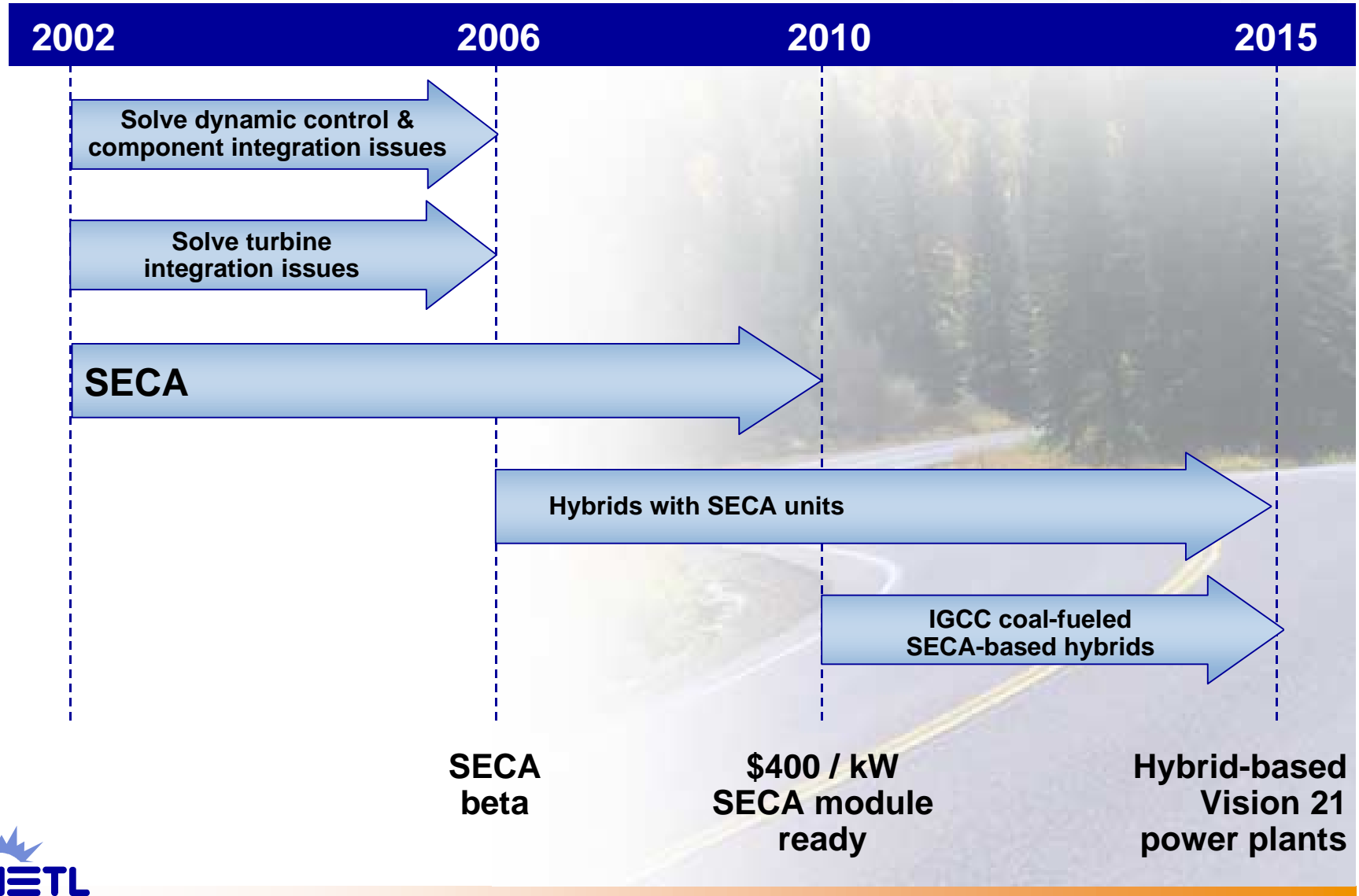
Honeywell International

SECA-Based Fuel Cell Hybrid

- Planar SOFC and direct-fired turbine
- Estimated efficiency 67%
- System net power 475 kW
- First SECA-based hybrid



Technology Road Map for Hybrid Power Systems



Vision 21

Ultra-Clean Energy Plant of Future

Energy Plants for Post-2015

- **Use available feeds**
 - Coal, gas, biomass, waste
- **Electricity primary product**
 - May co-produce fuels, chemicals, steam, heat



Goal

**Absolutely Minimize
Environmental
Implications of
Fossil Energy Use**



Approach

- **Maximize efficiency**
 - 75% gas-to-electric
 - 60% coal-to-electric
- **Near-zero emissions**
 - Option for carbon sequestration

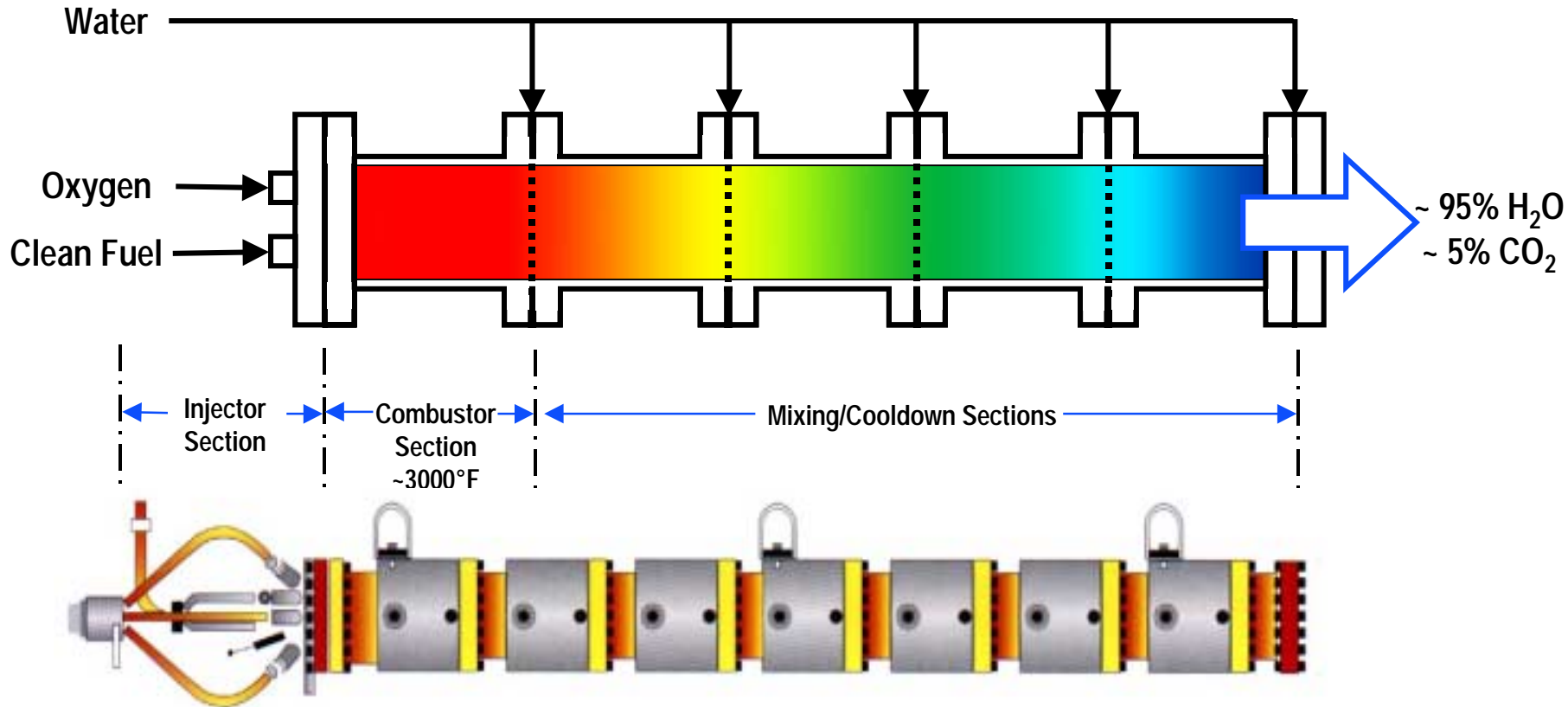


The Clean Energy Systems Gas Generator

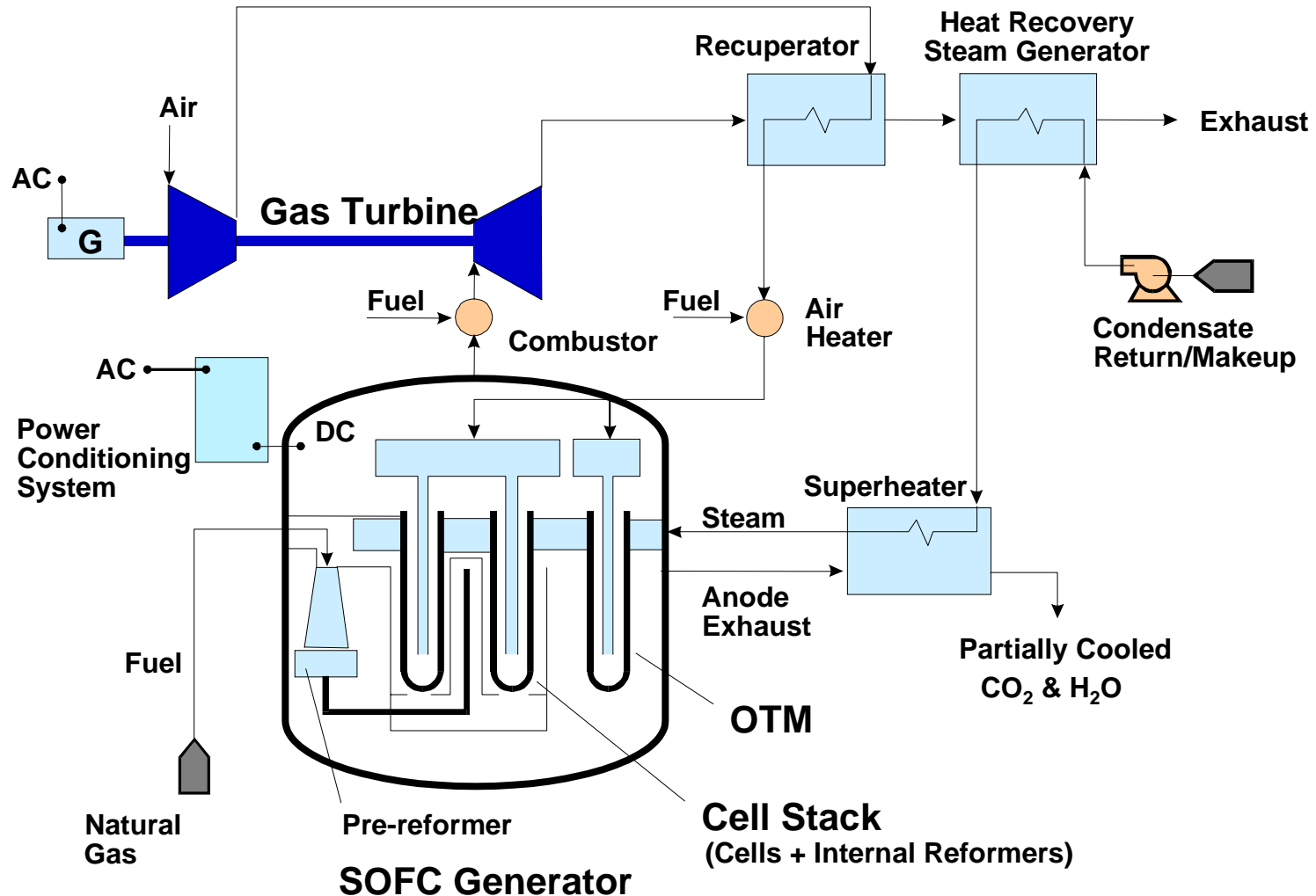
Typical Operating Ranges

1200 to 3200° F

1200 to 3200 psia



Siemens Westinghouse - Praxair Zero Emission Power System



Source: Siemens Westinghouse Power Corp.

Strategic Center for Natural Gas

A Vision for 2015

Putting the Pieces Together



**SECA-Based
Fuel Cells**



**Gasification with
Cleanup & Separation**



Vision 21 Power Plants



Optimized Turbines



**Carbon
Sequestration**



**System
Integration**

www.netl.doe.gov/scng

The screenshot shows a Microsoft Internet Explorer browser window displaying the Strategic Center for Natural Gas website. The browser's address bar shows <http://www.netl.doe.gov/scng/>. The website header features the NETL logo and the text "NATIONAL ENERGY TECHNOLOGY LABORATORY STRATEGIC CENTER FOR NATURAL GAS". A navigation bar includes links for Home, Search, Site Index, and Feedback. The date "May 12, 2002" is displayed in the top right corner.

The main content area is titled "The Strategic Center for Natural Gas" and includes several sections:

- Natural Gas Infrastructure Reliability Industry Forums**: The Strategic Center for Natural Gas (SCNG) at the NETL will conduct a series of Natural Gas Infrastructure Reliability Industry Forums in September 2002. [Read More!](#)
- Natural Gas Technology – Investment in a Healthy U. S. Energy Future**: Time is running short to register for the "Natural Gas Technology—Investment in a Healthy U. S. Energy Future" conference. [Read More!](#)
- DOE Kicks Off "Deep Trek" to Develop Deeper, Smarter Drilling Technology**: To develop a new high-tech "smart" drilling system that can tap into deep reservoirs, the DOE is beginning "Deep Trek." [Read More!](#)

A circular diagram on the right side of the page, titled "Integrating All Elements of DOE's Natural Gas Research From Borehole to Burner Tip", lists the following components: Strategic Planning & Policy Support, Exploration and Production, Transmission, Distribution & Storage, Gas Processing & End Use, and Energy Conservation.

A "SIGN UP FOR THE SCNG NEWS" button is located at the bottom right of the main content area.

The footer includes a "Return to top of page" link, a "Last Update: 04/24/02" timestamp, and a list of links: What's New | SCNG News | Events | Contacts | Key Initiatives | Strategic Planning & Policy Support | Exploration & Production | Transmission, Distribution & Storage | Gas Processing & End Use | Energy Conservation | Projects | Links | Search | Site Index | Feedback | SCNG Home. Below these links are links for "Disclaimer" and "Privacy Statement". The footer also states "2002 National Energy Technology Laboratory U. S. Department of Energy".

